

A tooling design for rapid assembly of astral structures

Lin-ru Cui *,Yan Chu, Jing Chen, Ben-xing Dong, Shuang Yao,Xue-ting Chen
Jie-ling Ma,Pan Luo,Jiu-Yuan Xu,Chen Hao, Sheng-hong Ji

Beijing Spacecrafts Co., Ltd., Beijing, 100094, China

*Corresponding author e-mail: cuilr123@163.com

Abstract. most of the antenna support structures in communication satellites are closed or semi-closed box structures. The box structure is mainly composed of honeycomb sandwich structure (referred to as structural plate). Each structural plate is not connected structurally and is bonded to form a component. The configuration of antenna support structure is different, so the process of bonding molding needs to be positioned by special tooling designed for the interface of each structure plate. In this paper, a general positioning fixture is designed. Only according to different types of antenna support structure, the connecting plate is designed to realize the gluing assembly of different configurations of antenna support structure quickly and efficiently. The fixture can be applied to other satellite antenna support structures and similar products.

Keywords: antenna support structures; general positioning fixture; assembly tooling

1. Introduction

With the rapid Development of China's economic strength and comprehensive national strength, there are more and more satellites for various purposes[1]. In order to obtain the signal of micro-transmitting power on the ground, improve the capacity of information transmission and realize the high resolution of remote sensing, the size of various spacecraft antennas is increasing[2]. The configuration and size of antenna support structures are also different[3]. The antenna support structure is mostly closed or semi-closed box structure, and the box structure is mainly composed of honeycomb sandwich structure(referred to as structural plate). The structural plates have no structural connection, and the components are formed by gluing. the process of bonding molding needs to be positioned by special tooling designed for the interface of each structure plate. In order to ensure the precision of the antenna support structure interface, the special tooling needs the combination processing under the component state. How to improve the versatility of antenna support structure tooling to reduce production costs, shorten the assembly cycle of antenna support structure and ensure the assembly quality of antenna support structure has become an important research content in the field of antenna support structure assembly[4].

2. Product features

The interfaces of the antenna support structure on the satellite are distributed on each surface. Figure1 shows the schematic diagram of an antenna support structure. The whole structure is six structural plates glued together through surface. The external connections of each structural plate are pasted with Redux 420 adhesive to strengthen the corner pieces, with an external dimension of 1630mm*510mm*388mm, the spatial accuracy of the interface is generally $\Phi 0.1\text{mm}$ in order to ensure the accuracy of the product, considering the error accumulation in the bonding assembly process, the precision of the bonding assembly tooling of the antenna support structure is required to reach $\Phi 0.03\text{mm}$. The high accuracy of the tooling can be achieved by controlling the machining accuracy of each part of the tooling, and finally the tooling can be adjusted in place; it can also leave machining allowance for each part of the tooling, which can be machined as a whole after being assembled into a glued assembly tooling component. The previously designed bonding assembly tooling is a special tooling, and the tooling base plate provides a support plane. The tooling connecting plates are designed according to the distribution of component interfaces. The

tooling connecting plates are fixed on the base plate through locating pins. Each structural plate uses the threaded holes on the plate surface to fix each structural plate on the connecting plate through locating screws and threaded holes on each structural plate, and implements bonding and curing. This tooling is a special tooling for a product, it has no versatility for other models of products, and the production cycle of this scheme is long.

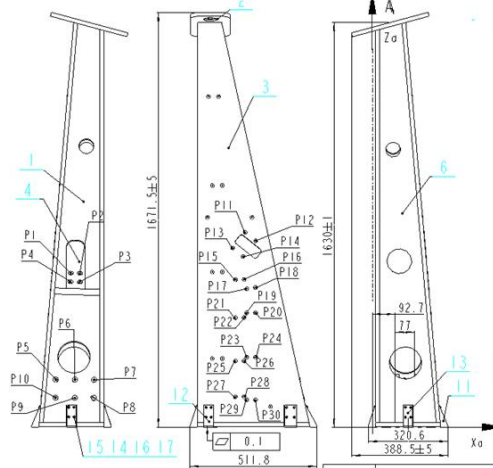


Figure1. Schematic diagram of an antenna support structure

3. Tooling design

After the parts of the bonding assembly tooling are processed in place, the assembly and adjustment guarantee or the combined processing under the state of the bonding assembly tooling components can ensure the accuracy requirements of the positioning hole, but the processing cycle is long, the cost is high, and the tooling is not universal. In order to improve the versatility and assembly speed of the bonding assembly tooling, and achieve the effect of building the bonding assembly tooling with high efficiency and low cost, the tooling design scheme is optimized, and the general parts of the bonding assembly tooling are designed, mainly including: positioning platform, standard column, positioning slider and positioning pin. Place the positioning slider in the longitudinal and transverse T-shaped slots of the positioning platform, and insert the positioning pin into the two pin holes 90° on the flange under the standard column. At this time, the position of the standard column has been fixed. For the interface position of the antenna support structure of different stars, it is only necessary to design a special positioning adapter plate to fix it on the end face of the upper flange of the standard column.

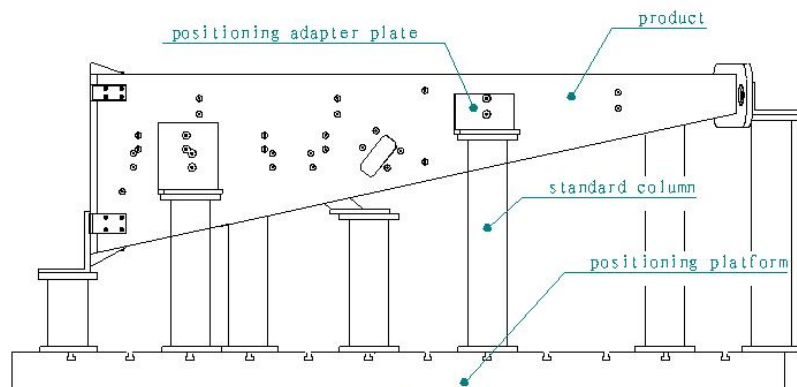


Figure 2.Schematic diagram of bonding assembly tooling

3.1 Positioning platform

The support plane provided in the bonding assembly tooling of antenna support structure needs to be rigid, therefore, the positioning platform made of steel is selected. M12 standard T-grooves are opened on the positioning platform with a spacing of 150mm in the vertical and horizontal directions, as shown in Figure 3, the inner cavity of the T-groove is required to meet the requirements shown in Figure 4, the smooth inner cavity is convenient for the movement and positioning of the positioning slider. The four corners of the positioning platform are provided with reference pin holes and lifting holes.

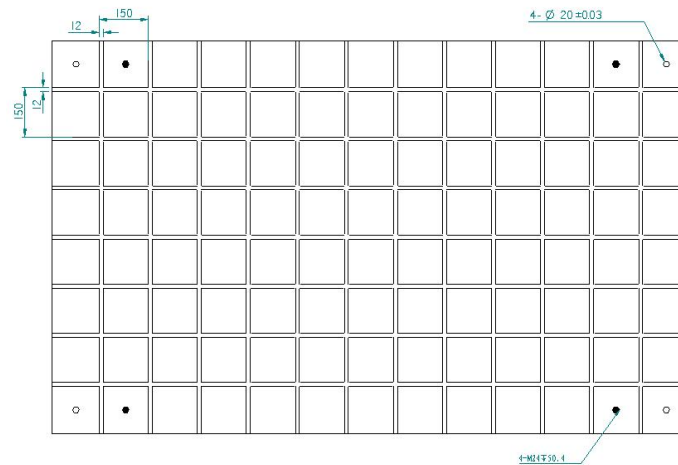


Figure 3. Platform bottom plate

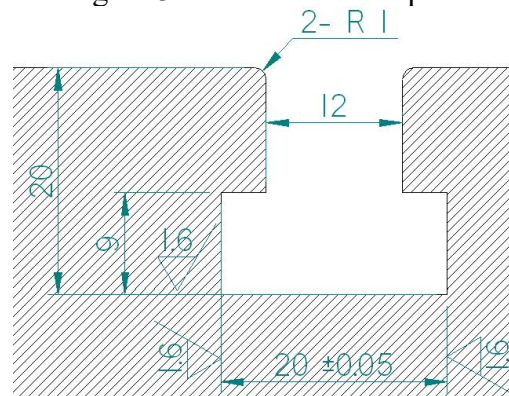


Figure 4. Requirements for T-groove

3.2 Standard column

According to the overall dimensions and joint positions of the antenna support structure, the columns with standard height are designed to ensure that the columns of different specifications can be spliced to the position close to the positioning interface on the product through lapping. All columns are in the form of welded flanges at both ends of the steel pipe, and the flanging of the flange is uniformly provided with positioning pin holes and fastening light holes. The height specification of standard column is shown in the table below.

Table 1 Height specification of standard column

Number	1	2	3	4	5	6	7	8	9	10
standard column code	H100	H200	H250	H300	H350	H400	H450	H500	H550	H600
standard column height H1/mm	100	200	250	300	350	400	450	500	550	600

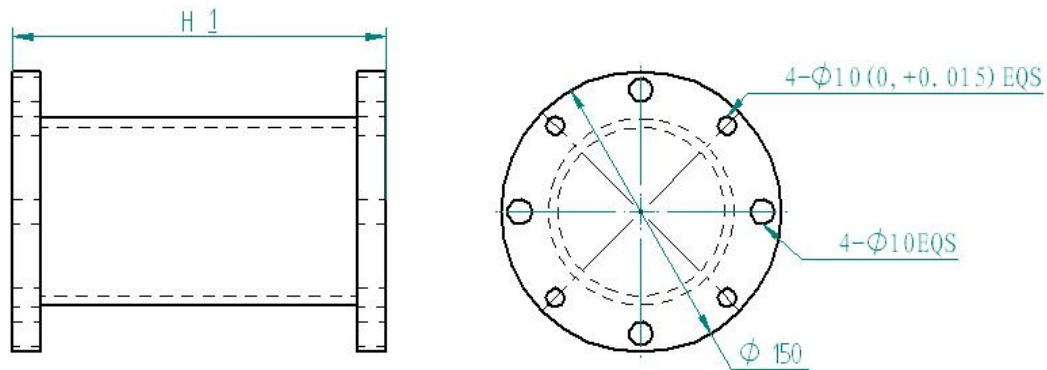


Figure 5.Schematic diagram of standard column

3.3 Positioning slider and positioning pin

In order to locate the relative position of the standard column and the positioning platform, a positioning slider and a positioning pin are designed, as shown in Figure 6. The positioning slider can slide in the same T-shaped groove of the positioning platform. When a positioning slider in both vertical and horizontal directions is aligned with the positioning pin hole on the flange of the standard column, insert the positioning pin for positioning, and the position of the standard column can be fixed. As shown in Figure 7, by controlling the dimensional tolerance of the positioning slider and the positioning pin, ensure that the positioning dimensional tolerance of the standard column is less than 0.55mm.

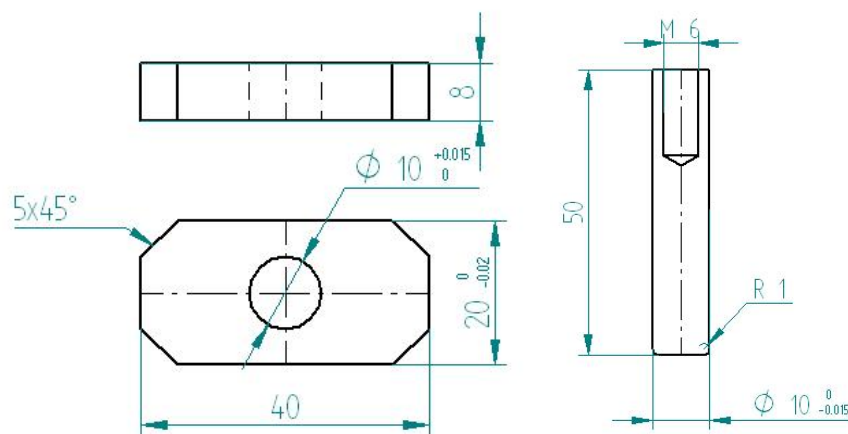


Figure 6.Schematic diagram of positioning slider and positioning pin

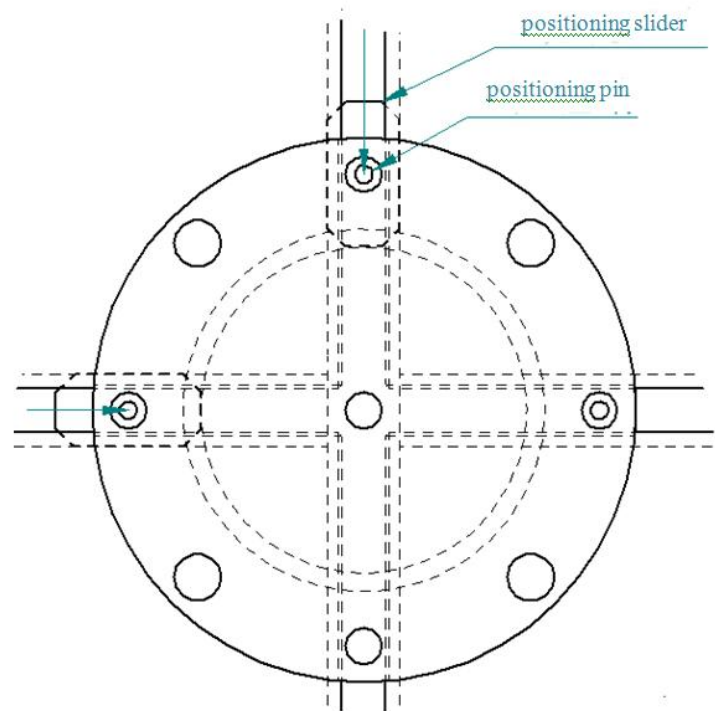


Figure 7.Schematic diagram of precise positioning of standard column with positioning slider and positioning pin

3.4 Positioning adapter plate

According to the interface distribution of the product, the positioning adapter plate connecting the product and the standard column is mainly L-shaped baffle. One side is close to the star body and firmly positioning through the interface on the star body, and the other side is close to the standard column, positioning through the pin hole on the standard column, and fastened with the standard column with screws. For structural plates in special positions, according to the distribution state of the interface on the product, an adaptive positioning adapter plate is designed to realize the positioning connection between the standard column and the product.

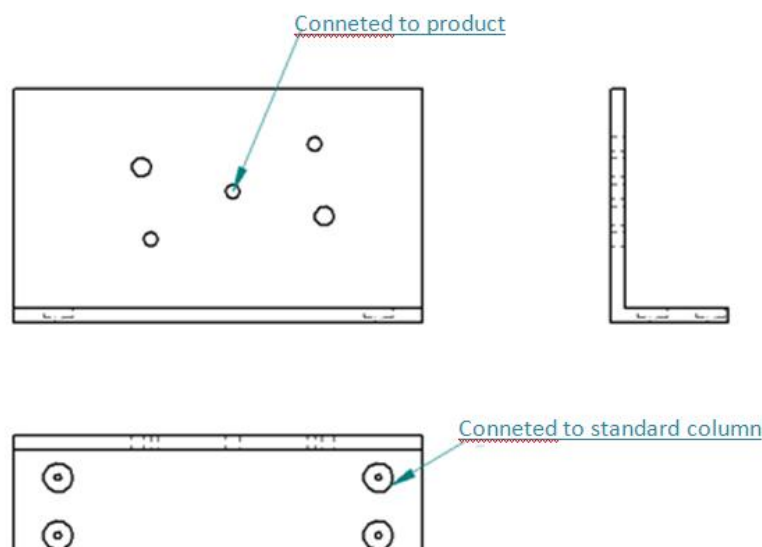


Figure 8.Schematic diagram of positioning adapter plate

4. Application validation

The gluing assembly of a certain type of antenna support structure implemented by the above tooling design scheme is show in Figure 2. The accuracy of the measured value of the product interface meets the position accuracy of the design index of $\Phi 0.1\text{mm}$, and then two types of antenna support structures are assembled by using this set of tooling. As shown in Figure 9, the interface accuracy of the product meets the position accuracy of the design index of $\Phi 0.1\text{mm}$, the production efficiency is increased by 150%, and the tooling production cost is reduced by 60%.

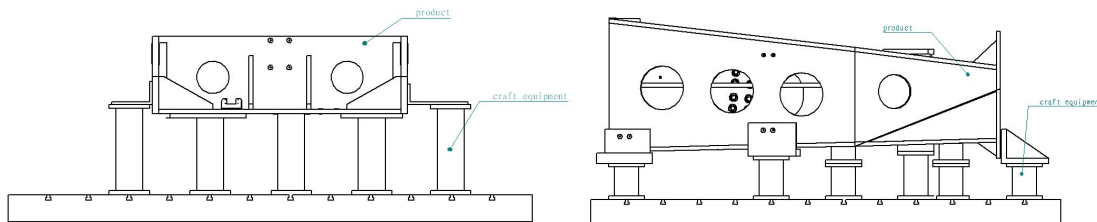


Figure 9. Schematic diagram of general tooling bonding assembly for other types of antenna support structures

5. Conclusion

This paper introduces a tooling device for rapid assembly of antenna support structures, which can realize high-efficiency, low-cost and high-precision bonding assembly of different types of antenna support structures. After practical application on three types of antenna support structures, the device improves the production efficiency of antenna support structures with low cost on the premise of ensuring product accuracy. Later, it will be popularized and applied to other types of antenna support structure spacecraft assembly.

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